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LONG-RANGE FORECASTING

By C. E. P. Brooks, D.Sc.

The detailed forecasts for 24 hours or less, based on synoptic charts, are designed to meet the requirements of aviation and shipping, as well as the day-to-day needs of the general public. For some purposes, however, such as agriculture, the issue of forecasts in more general terms for a longer period would be of great value, and in recent years investigations have been carried on in various parts of the world with this object in view. The forecast aimed at would cover a period from a week to a month, and would be based on the *type* of pressure distribution anticipated and the principal changes which it is likely to undergo during the period covered. The general character of the weather could then be filled in from any required aspect, but not the detailed weather conditions on any specified date. This is the definition of a "long-range forecast", intermediate in scope between the detailed synoptic "short-range forecast" and the generalised "seasonal forecast" which is mostly limited to the departure from normal of one element, rainfall or temperature, over a period of three months or more. Although under favourable conditions the daily forecast may be extended, in the "further outlook", over a period of three or four days, the ordinary synoptic methods are not suitable for regular long-range forecasting, and it has been necessary to seek for other lines of attack.

We may leave out of account here the many weather prognostics such as the oak and the ash, or St. Swithin of dubious memory. More debatable—or at least more debated—are the famous Buchan cold and warm spells, but whatever we may think of "St. Buchan",

every table of climatological normals is in one sense a long-range forecast, for it assumes that what has happened in the past will happen again in the future. In a climate such as that of Britain, however, the "normal" is not always a very good guide even for the average weather of a whole month. The range of variation of the monthly means may be considerable, while the normal itself is not always the most probable value. These difficulties are especially important in those elements, such as rainfall, which have a lower limit but no definite upper limit, and also in cloud amount, where figures of 0 and 10 may occur more frequently in the individual observations than intermediate amounts.

The best way to express climatological data as a guide to probable weather is the frequency table or frequency diagram, which shows the percentage of the observations falling within definite limits. This gives at once the limits beyond which occurrences are so rare that they may be ignored for practical purposes. Another example of a frequency table is one giving the percentage of winds from different directions; this can be made more useful by giving also the frequency of different forces from the various directions. Frequency tables may be useful guides in regions of settled weather, but they are of comparatively little value for forecasting in the highly variable climates of the temperate storm belts.

What we have to do then, is to take the climatological normals as a basis, and seek to foresee how the actual conditions over a month or a season will depart from this standard. This is the basis of a seasonal forecasting, or "foreshadowing" by correlation of which India is the outstanding example.

The method in use was developed by Sir Gilbert Walker, and is based on the hypothesis that the weather in one part of the earth depends on preceding conditions in the same or other parts of the earth. In its inception this method was founded on physical reasoning, for it was supposed that heavy snowfall in the Himalayas in winter would inhibit the southwest monsoon. In practice, however, it was soon found that this was only one of many factors involved, and these factors were themselves inter-related to such an extent that the problem of tracing out even the more important connexions by physical reasoning proved too complex. Sir Gilbert Walker accordingly developed an alternative method. He collected series of data for a considerable number of places in all parts of the world, mostly in the form of means for three-monthly seasons, and worked out correlation coefficients between each of these and all the others, for the same season and for three and six months before and after. This was a formidable task but the labour involved was minimised by specially devised methods of calculation. From these correlation coefficients he picked out those which satisfy mathematical criteria of probability, and the process of constructing a formula for seasonal forecasts for any specified region then became almost mechanical.

This method at first sight appears crude and unscientific, but further reflection suggests that it has a real physical basis. The main variations of weather in any part of the world are associated with variations at certain key stations termed " centres of action ". Sir Gilbert Walker's method is to locate these centres of action by an exhaustive preliminary survey and then to go straight to his final objective, cutting out the intervening chain of cause and effect, which is generally tangled and obscure. The method is however not really applicable to the storm belts of temperate regions, where the changes of weather type are so rapid that " seasonal " forecasts, generalising the weather over a period of three months, are of comparatively little use.

Another possibility to which a great deal of attention has been devoted is forecasting by means of periodicities or " weather cycles ". At first sight the simplest and surest of all methods, periodicities have proved in practice to be of little value. For example, Brunt found that when all the best developed periodicities in the departures of the mean monthly temperatures at Greenwich from normal were eliminated, the effect was merely to reduce the standard deviation from 2·8° to 2·6° F., an almost negligible amount. It is true that when Brunt used these periodicities to calculate the temperature for a few years ahead, his calculated curves showed a fair measure of agreement with the observed values, but this was probably a temporary accident. Nearly every attempt at forecasting by periodicities, especially in temperate latitudes, has speedily broken down. The reason is that weather cycles are not true periodicities in the mathematical sense, but are subject to variations of phase, amplitude and length. An apparently well-established cycle may die out completely and be replaced by another of different length, perhaps to reappear suddenly a few years later with a complete reversal of phase. Thus for about half a century the rainfall of England was dominated successively by cycles of five, three and two years, each of which in turn broke down completely. Until the laws, if any, which govern the succession of cycles have been made out, periodicities will remain untrustworthy guides to weather.

In tropical regions a certain amount of success has however been attained. About twenty years ago the Meteorological Office gave the Government of Gambia a successful qualitative forecast of the annual rainfall for the next few years, based on a combination of cycles. Recently a three-year cycle has been used in Java, but this is subject to changes of phase, apparently due to the interference of a cycle of seven years.

Owing to this general untrustworthiness, curves calculated from periodicities can be extended only for a short distance into the future, and the calculations need to be constantly revised. This method has been applied to curves of barometer readings, by Vercelli in Italy and on a more extensive scale by Weickmann in central Europe. The theory is that a curve dominated by periodicities will

have nodes or " points of reflection ", the curve after the node resembling that before the node, either simply reversed or reversed and inverted. If the nodes occur at the same time over a considerable area, there will be an ordered sequence of weather charts which can be used for detailed forecasts. Weickmann gives examples of such series extending over several months and in some cases a year, but it is very doubtful if the method could be used in practice owing to the difficulty of recognising in time the points of reflection, and the uncertainty as to how long the waves will persist. Further, it is to be noted that these waves are not well developed near sea coasts, so that the idea holds little promise for the British Isles.

Since deductive methods proved comparatively unsuccessful when applied to temperate latitudes, some attention has been given in this country and in Germany to empirical methods of long-range forecasting. The underlying assumption in these methods is that similar causes produce similar results, so that if at two different times the general atmospheric situation is clearly similar, the subsequent developments should also run parallel. This empirical method was in fact the basis of daily synoptic forecasting until comparatively recently, as is shown for example by the publication of Gold's " Aids to Forecasting " in 1920. For long-range purposes however it is necessary to distinguish between the persistent or structural features of the weather maps, including slow-moving anticyclones and centres of cyclonic activity, and temporary features such as rapidly moving secondary depressions. The temporary features can be smoothed out by making average maps over a period of time, from ten days to a month. Since this smoothing process also gives prominence to the permanent or " normal " seasonal features of the pressure map, the latter are eliminated by using differences from normal instead of the actual means of pressure. Hence the basis of the empirical method in this country has been the study of a series of monthly charts of deviation of pressure from normal over the northern hemisphere.

The direct application of the principle of causality proved disappointing, for even if the pressure charts for say January in two different years were closely similar, the charts for the following February might be widely divergent. The reason for this is probably that apparent similarity may cover considerable differences in the succession of changes within the month.

In Germany F. Baur got over this difficulty by using ten-day intervals instead of months and analysing a succession of charts for overlapping ten-day periods in great detail by a combination of synoptic and statistical methods. He also makes use of upper air data, on the hypothesis that the general weather changes must be governed by movements of air masses in the stratosphere, and he has in fact obtained considerable success by using the " steering " effect of the high-level pressure distribution to forecast the movements of areas of rising or falling pressure at the surface. A more detailed account of Baur's methods is given by Sir Gilbert Walker in the

Quarterly Journal of the Royal Meteorological Society for October 1937. They would be difficult to apply in western Europe because of the lack of regular upper air observations over the North Atlantic.

In this country the month was retained as the unit, mainly because monthly means of pressure for a large number of places were more readily available than means for shorter periods, and the changes from one month to the next were studied cartographically. A chart of pressure anomalies for a month generally shows one or more closed areas in which pressure reaches a maximum deviation above or below normal. These are analogous to the anticyclones and depressions of an ordinary daily weather map, and like the latter they generally occupy different positions on successive charts. Examination of a series of over 600 monthly charts showed that these centres of excess and deficit have a tendency to move from west to east, like ordinary anticyclones and depressions but much more slowly. In some parts of the northern hemisphere, for example from the Azores to the British Isles, there appears to be something approaching a definite track, but further north the movements are rather irregular. Unfortunately the life-history of a single " centre " is in general only from one to three or four months, and they sometimes appear or disappear abruptly. Their value for empirical forecasting is thus very limited.

Future progress along this line requires investigation in two directions, to discover if possible the physical significance of these centres of excess and deficit and their movements, and to relate these comparatively local changes of pressure to more widespread and slower seasonal changes in the atmospheric circulation.

Of the significance of the centres little can be said at present. In some cases they may be due to phenomena at a high level, possibly in the stratosphere. This is a feasible explanation of the centres of excess which tend to move northeastward from the Azores in spring, and which appear to be offshoots from the high-level warm Azores anticyclone. In higher latitudes however they may possibly represent the movements of large masses of cold or warm sea water. Both possibilities require examination in greater detail than has hitherto been attempted.

In the second direction rather more has been done, especially in connexion with variations in the amount and distribution of Arctic ice and subsequent pressure changes. For example, in January and February, 1938, the pressure distribution favoured steady winds from the south across the Arctic coasts of eastern Europe and western Asia. The result was to introduce much warm water into the Arctic and drive back the limits of ice. The rise of temperature and consequent fall of pressure in the Arctic gave a tendency for a northeastward shift of the whole pressure system of the North Atlantic, bringing the Azores anticyclone nearer to the British Isles and dominating the movements of the " centres " in the spring months. This was the immediate cause of the drought in the British Isles, and

in this particular case it would have been possible to forecast the occurrence of drought from general considerations and to modify the forecast from time to time by reference to the monthly charts. This is only an isolated example however in which one factor dominated the situation and further investigation would be required to enable similar deductions from the general situation to be made regularly. Nevertheless this method probably presents the best prospect for successful long-range forecasting in the British Isles. It may also be practicable in south temperate regions, especially Australia and New Zealand, but the lack of data for the ocean to the westward would prove a handicap.

Note on some unusual observations of Cirriform Cloud

By S. T. A. Mirrlees

About 1530 (all times mentioned are G.M.T.) on Sunday, August 15th, 1937, at Newport-on-Tay, I observed what was apparently a fine display of hooked cirrus to southward. On fetching dark glasses and studying the clouds in the zenith I was surprised to see the cirriform cloud passing below a broken sheet of high stratocumulus which was moving from the opposite direction. With the aid of a hastily improvised nephoscope the following observations were made at 1600 :—

Stratocumulus (estimated at 7,000 feet) moving from NNW at 15 radians/hr. " Cirrus " (at some level slightly below the stratocumulus) moving from SSE at 19 radians/hr.

The observations were made on clouds in the zenith or nearly so, the " cirrus " at the time being arranged in parallel bands lying E–W, and appearing as coarsely grained fibrous type.

The appearance suggested a wave motion but cirrus with more developed vertical structure was seen at 1630, moving fast from about SW and at 1900 similar masses were seen to SW still apparently moving fairly quickly from SW. None of the " cirrus " passing across the sun gave any halo phenomena. Towards dark the stratocumulus had become lower, but was still moving from a northerly point, and the cirriform cloud was not seen.

Mr. D. W. Cruickshank made the following observations :—" From a point about 2 miles NE of Leuchars on Sunday afternoon about 1500–1530 I observed hooked cirrus towards the south. As far as I could judge, the cirrus seemed to be moving towards the NW. Above it, moving in almost the opposite direction, there was what seemed to be altocumulus, some of it being lenticular, and at a height of about 10,000 feet. The cirrus was in parallel bands lying almost along the direction of motion. The clouds were almost between me and the sun so that it was difficult to see exactly, but they appeared to be moving at approximately the same speeds."

Mr. J. R. Sandison made the following observations :—" On Sunday, August 15th, 1937, at Tayport, about 5 miles north of Leuchars, I observed an unusual formation of cirrus cloud of *cirrus uncinus* type. The surface wind was W, force 3, and the lower cloud (5/10 fair weather Cumulus and Stratocumulus) was coming from approximately WNW. The cirrus which at about 1600 G.M.T. was

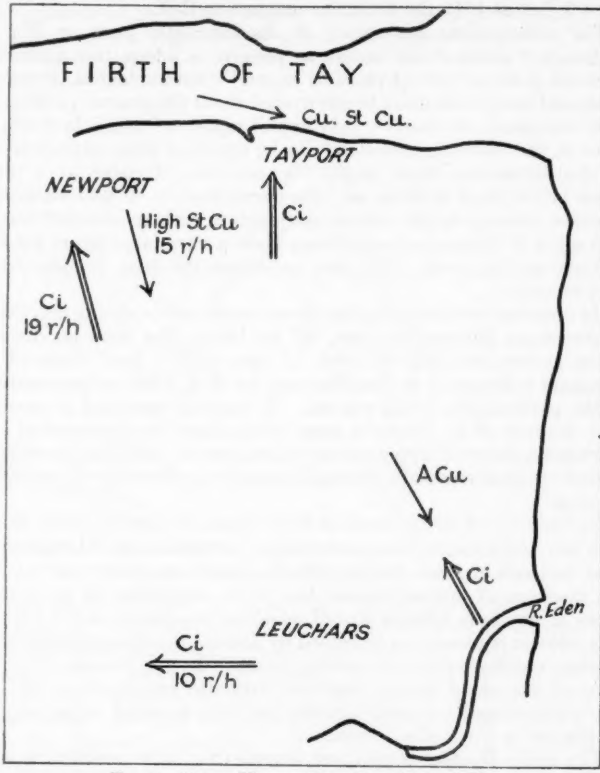

FIG. 1—CLOUD MOVEMENTS, AUG. 15TH, 1937.

moving from N–S and at a speed which I judged to be fairly rapid, first appeared in the NNW as fine white globular cloudlets arranged in thin parallel bands running E–W and from it long delicate filaments swept down and back towards N, appearing to pass below the stratocumulus, which was at a height of about 3,000 feet. Previous to this, at 1500 G.M.T., I had taken two photographs of the sky but unfortunately had exposed all my plates before the appearance of the cirrus."

Mr. G. Froude, at the Meteorological Office, Leuchars, observed at 1600 cirrus moving from E at 10 radians/hr. The sky conditions were :—total cloud amount 6/10, low cloud (fair weather cumulus and stratocumulus) 3/10 estimated at 3,000 feet, medium cloud (single layer of altocumulus), high cloud (cirrus and cirrostratus increasing and reaching above 45° altitude). The surface wind was WNW, force 3, but at 1615 the direction changed to ESE.

The observations are shown in diagrammatic form on Fig 1. Although " cirrus clouds cannot at present be adequately discussed from the point of view of physical causes " (Meteorological Glossary, p. 43) and much remains to be discovered about the general question of cirriform cloud any observer may expect reports of cirrus cloud which come in the following two classes to be regarded with scepticism :—

(*a*) observations which imply the presence of cirrus at a level much below what is taken as " the cirrus level "—in such cases the reported velocity-height ratio in conjunction with an assumed height of 5 miles (8 kilometres) sometimes gives a very large figure for the velocity of the cirrus. To save repetition the term pseudo-cirrus may be used ;

(*b*) observations indicating in the same sky cirrus clouds travelling in directions differing by, say, 90° to 180°. The term anomalous cirrus movements may be used. A case of this kind observed at Leuchars is described in this Magazine for May, 1934, no explanation of the phenomenon being reached. It may be remarked in passing that the flow of air shown in some of the later developments of the Norwegian theory of upper-air structure seems to imply the possibility of such cirrus movements, although synoptic confirmation is probably lacking.

Occurrences of cirrus cloud at lower levels are by no means rare ; they have on occasion been confirmed by measurement of height with pilot balloons or range-finder. Where there is no such confirmation the question of optical illusion has to be considered, as in certain types of sky it is difficult to tell which of two layers is the higher. (The illusion is sometimes increased by making the observation from a quickly moving vehicle or railway train.) In the present case the type of the cloud above, together with the independence of the observations make it quite definite that the so-called cirrus was in reality below the " alto " level.

The *Daily Weather Report* and records from other stations in east Scotland have been examined, but no evidence is found for the existence of a large-scale discontinuity at lower levels, which, if it had existed, would presumably have been shown by disturbances on the barograms. The synoptic charts show a ridge of high pressure crossing the British Isles, while a slow-moving cold front which was off west Scotland on the evening of the 13th extended, on the afternoon of the 15th, from NNW to SSE about 200 miles off the east coast of Scotland. A pilot balloon ascent at Aberdeen showed north-westerly winds to above 8,000 feet ; at 18,000 feet the wind was 145°,

24 mi/hr, and at 18h. cirrus cloud was moving from 140° with an estimated speed of 45 mi/hr. A pilot balloon ascent at Leuchars at 1100 showed light north-westerly winds up to 3,000 feet.

Fig. 2 shows air trajectories deduced from anemograms (except for Leuchars, where there is no anemograph) for the period ending at 1700. The anemograms and barograms show only insignificant appearances of wave formations, although the appearance of the "cirrus" gave a suggestion of a wave or group motion.

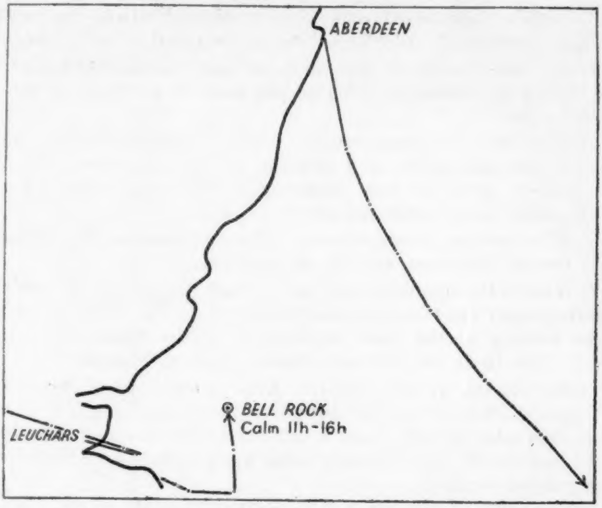

Fig. 2—Air Trajectories (17h), Aug. 15th, 1937.

The sea-breeze appeared at Leuchars at 1615 hours as a change in direction of wind from WNW to ESE inside, say, 30 minutes and probably after the time of observation of the low "cirrus". There is some rather vague evidence, though not on this occasion, pointing to the possibility of turbulent conditions at a surface separating "sea-breeze" air from warmer overlying air at some 2,000 feet above the Tay Estuary, conditions which in a suitable distribution of humidity might be indicated by cloud developments, and frontal invasions of sea-breezes have been studied at various places (e.g. Danzig). I have occasionally observed here, on days of vigorous convection with light winds, the early stages of formation of cumulus cloud at a fairly high level, give an appearance resembling two sets of cirriform clouds with a large relative motion.

However, while an explanation of the banded cirrus on the hypothesis of breaking waves on a sea-breeze front is tempting, it involves a certain amount of arguing in a circle, and is not justified by the aerological data available.

Questions for further investigation might be put in the following form; comments in brackets are based mainly on examination of a number of reports in the *Meteorological Magazine* from 1920 onwards:—

(1) Is the occurrence of "cirrus" at low levels confined to any particular region? (Probably not, in British Isles.)

(2) Are occurrences of anomalous cirrus movements similarly localized? (Little evidence, but probably not.)

(3) Is the occurrence of pseudo-cirrus associated with any particular synoptic situation? (Region behind an occluded or cold front.)*

(4) Are occurrences of pseudo-cirrus and of anomalous cirrus movements expressions of different processes, or are they correlated to any extent?

(5) What are the circumstances in which a cloud of water drops presents the appearance of a cloud of ice crystals (except for the fact that it gives no halo phenomena) the temperature of the environment being sometimes above 32° F.?

(6) What are the circumstances in which cirrus extending through great vertical distances, extends to low levels?

(7) What is the significance of the fact that the form *cirrus uncinus* is so frequently mentioned in observations of pseudo-cirrus, and what is the bearing on the usual explanation of the formation of this type? (Are there two distinct uncinus-forming processes?)

I have put the questions in this form in the hope of suggesting some points for debate; a further point is that much might be learnt if the forecaster himself could spend more time in observing cirrus (and other clouds) with the aid of some less primitive apparatus than is at present available.

In the course of discussion of low-level cirrus, Mr. G. A. Clarke, of Aberdeen Observatory, has kindly put at my disposal two interesting photographs, which are reproduced by courtesy of Mr. Clarke, along with his notes on the formations.

Fig. 3 "is a case (in summer time—date uncertain) of a band of cirrus, whose threads are hanging downwards and only slightly inclined to the vertical except at the extreme foot. These threads seemed to originate in and proceed from a rather dense band of white cloud not unlike an "anvil" from some cumulonimbus, though no cumulonimbus was visible. The interest here lies in the fact that the threads extend some thousands of feet vertically. As the cloud passed overhead it appeared as a narrow band and eventually, due to perspective, resembled ordinary thread-cirrus. The dark band at foot of photo is the upper edge of a bank of dark stratocumulus at perhaps 2,500 or 3,000 feet."

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* Since this was written an observation in the region behind a warm front has come to hand. See note by Mr. Cruickshank on p. 267, also *Daily Weather Report*, International Section, for 18h. on March 11th, 1938. A warm front some 200 miles east of Leuchars is indicated.

[*Facing page 266*

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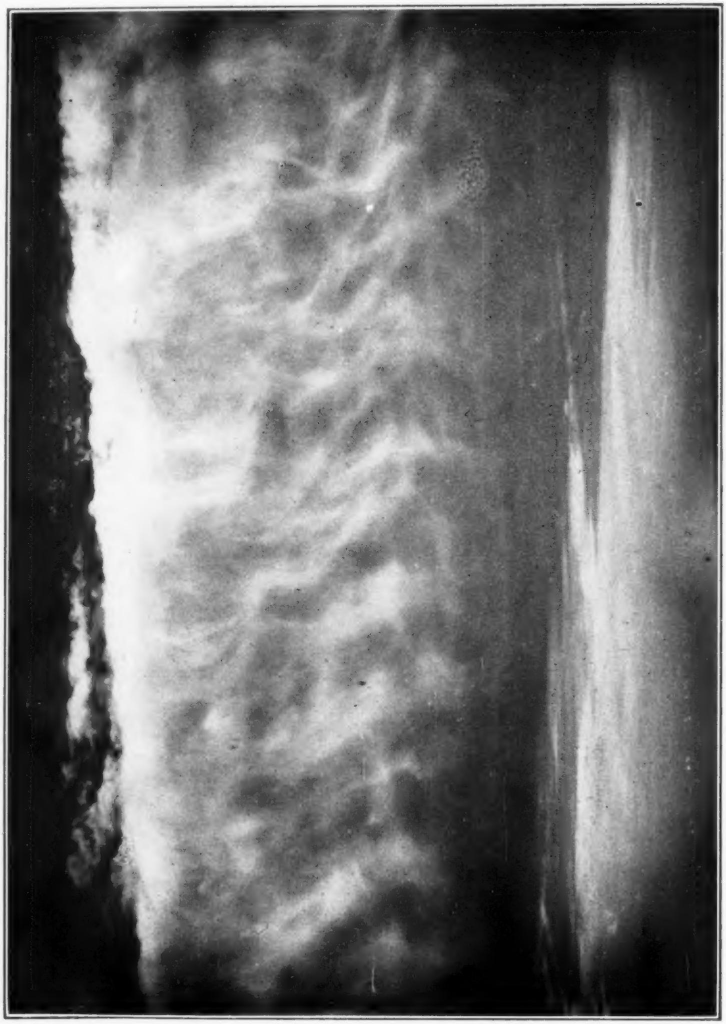
FIG. 3.—CIRRIFORM CLOUD WITH NEARLY VERTICAL FILAMENTS.



Copyright: G. A. Clarke

FIG. 4.—CIRRIFORM STRUCTURE IN CLOUD OF ALTOCUMULUS OR ALTOSTRATUS TYPE.

There are some points here in common with Mr. Sandison's observations mentioned above; compare also the "cascade" of cirrus mentioned by Mr. D. L. Champion in *Meteorological Magazine*, June, 1936, p. 117.

Fig. 4 "is perhaps the most interesting of all. A sheet of altocumulus to altostratus (C_M7) was advancing from eastward (in which direction the observer is looking). From its leading edge brightly illuminated threads are descending. Perhaps these may be streams of snow. But the relatively dark sheet of altostratus against which they stand out, and beyond which the lighter sky is showing again, as it moved overhead broke up into altocumulus and rapidly dispersed, leaving the long wisps of apparent cirrus showing white against the blue sky."

An advance in the interpretation of observations of cirrus cloud, as in other problems of the upper air, appears to await the extension of aerological observations in general.

Observation of "Cirrus"-Form Cloud below Cumulus

By D. W. Cruickshank

At about 1800 on Friday, March 11th, 1938, from the village of Leuchars, I happened to notice a fairly large patch of cumulus and stratocumulus, with what appeared to be cirrus streamers underneath it. The prevailing type of low cloud at the time was large cumulus with stratocumulus and the height was about 3,000 feet. The patch to which my attention was drawn was due west and at an elevation of about 10°. Its position would have been approximately above the north-west slopes of Lucklaw Hill. In shape the mass was roughly lenticular with the ends "blunted" considerably, with the longer axis in an approximately SSW–NNE direction. The sun had set by this time though it was still shining on a few isolated patches of very high cirrus (hooked) and cirrocumulus to the west. The surface wind at the time was S.W, 5 mi/hr. and the wind at 3,000 feet (from a pilot balloon ascent) at 1630 was 45°, 2 mi/hr.

Besides the large cumulus and stratocumulus, there was also a certain amount of altocumulus in a single layer, and a considerable amount of hooked cirrus with a few small patches of cirrocumulus. My attention was first drawn to the low "cirrus"-form cloud by the colours on one of the cirrocumulus patches. This patch was above the southern end of the mass of cumulus and was just lighted by the setting sun. The centre of the cloud was pale pink in colour, this colour being uniform to the edge of the cloud. There a band of bright green took its place. The green colour was on the "south," "west" and "north" sides of the cirrocumulus. The two colours did not merge gradually into each other but the dividing line was quite sharply defined. The colouring lasted for about ten minutes till the sun's rays were off the cloud.

Underneath the patch of cumulus cloud I happened to notice what appeared to be cirrus streamers, in appearance exactly like the true hooked cirrus also present. The " low cirrus " passed underneath the smooth base of the cloud and turned up the near side, into which they seemed to merge. The direction of these streamers was not quite at right angles to the axis of the main cloud mass but roughly in a NW–SE direction. This fact was impressed on me because this was roughly the direction of the true hooked cirrus. (A nephoscope reading at the Meteorological Office, Leuchars, at 1800 gave 310° for the direction of motion of the cirrus.) The " low cirrus " lasted for about four minutes and then the underneath surface of the main cloud with which it was associated began to change quickly. Instead of being smooth it became much agitated, and corrugations running at right angles to the length of the cloud took the place of the " cirrus." The near edge of the cloud was also involved as it seemed to be " boiling " and turning over a horizontal axis. Owing to the failing light I could not see how long this lasted. At no time while I was observing the cumulus cloud did the sun shine on it as the sun was already below the horizon.

Waterspout and Intense Thunderstorm in Southwest Scotland on August 11th, 1938

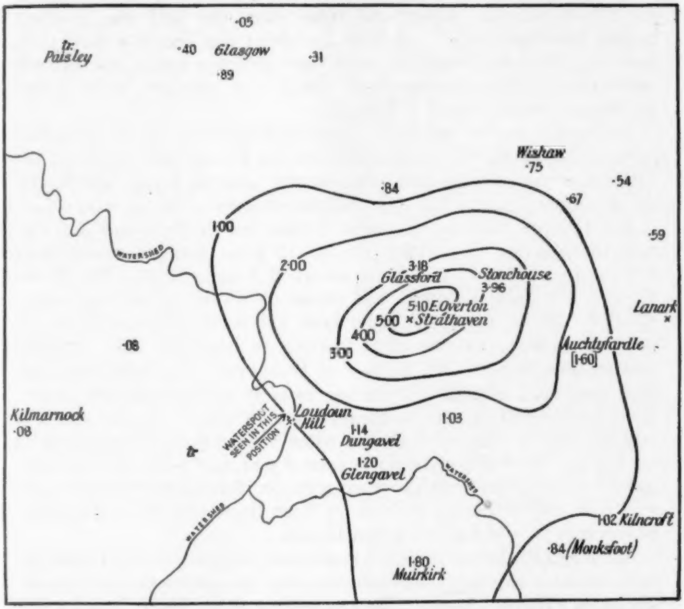
By A. H. R. Goldie, D.Sc.

A waterspout was observed on the borders of Lanarkshire and Ayrshire on August 11th. In view of its apparently close connection with a patch of intense precipitation centred eight miles to northeast, in the direction towards which the upper end of the spout pointed, the complete circumstances of the case seem worth putting on record.

Mr. P. E. Kirton of Dungavel, near Strathaven in southwest Lanarkshire, described the waterspout in these terms : " At 4.10 p.m. what appeared to be a trunk-like structure of cloud shot out from near the edge of a nimbo-stratus cloud ; its length was enormous. The colour was white, it appeared to be suspended from the cloud and its direction was earthwards and running obliquely between the points northeast and southwest. From near the point of its origin the western sky was quite clear, with sunlight. Thunderstorms were approaching from the directions northwest and northeast and have proved to be of considerable intensity and duration. The phenomenon lasted nineteen minutes and no movement or alteration took place in its structure ; its disappearance was a matter of seconds and it appeared to be drawn straight back into the clouds. At the point of origin it was of considerable bulk and at its termination of vanishing point. This phenomenon was witnessed by a large number of estate workmen, many of them old men who declared that ' they had never witnessed such a thing before.' " In reply to an inquiry, Mr. Kirton said that the upper end which seemed to be directly above Loudoun Hill pointed towards

northeast, and he supplied a sketch. The approximate position is indicated on the map, Figure 1. No movement was apparent during the whole of the nineteen minutes during which the phenomenon was under observation.

On the same afternoon flooding from heavy rain caused a landslide on the L.M.S. Railway between North and Central Stations, Strathaven. The landslide occurred between about 6.20 p.m., when a train passed safely, and 6.50 p.m., when the following train was



Scale: Approx. 8 miles to 1 inch

FIG. 1—DISTRIBUTION OF RAINFALL IN SOUTHWEST SCOTLAND, AUG. 11TH, 1938.

derailed. A subsidence took place also on the railway line leading into Strathaven from Stonehouse. Flooding throughout the Strathaven district was extensive, roadways in various places were blocked and fields inundated. The thunderstorms of the same afternoon caused very considerable damage and flooding in many places in southwest Scotland, but the object of this note is primarily to describe what took place in the Strathaven district where the intensity was phenomenal. The places to which reference is made are shown on the map, Figure 1. All times quoted are Summer Time.

At East Overton House on the east side of Strathaven the precipitation from 3 p.m. to midnight was 5·10 inches. "Hailstones

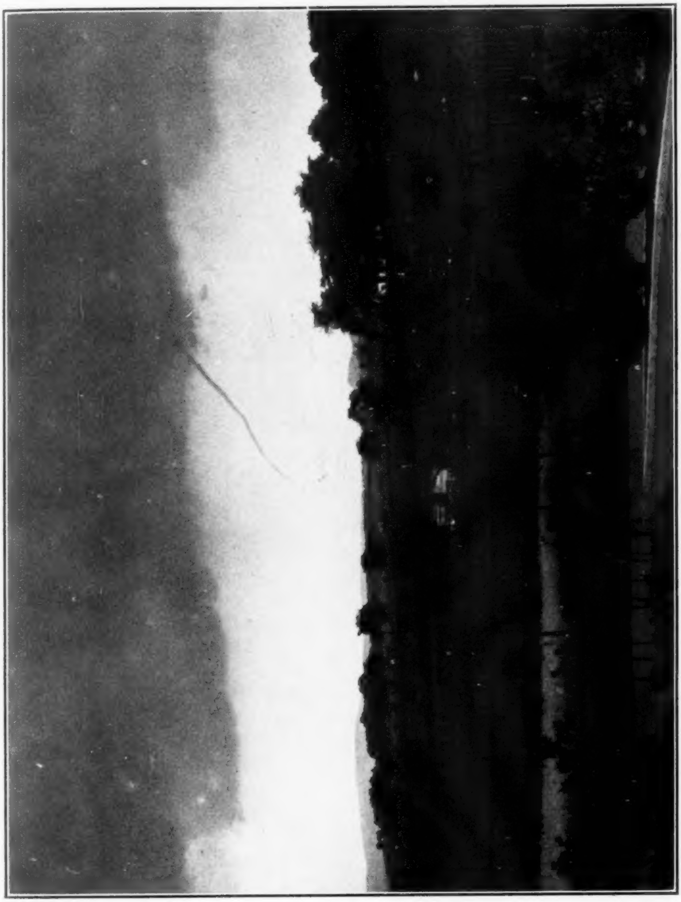
which came for about two hours were the size of pullets' eggs". The drive was washed down to the road, the garden ruined, and potatoes almost washed out of the ground. The gardener, Mr. W. Anton, says that at 3 p.m. there was a heavy shower at East Overton, but not in the town of Strathaven; at 3.45 p.m. heavy hail started and it continued for about 2½ hours. The tennis lawn which is surrounded by banks 10 to 14 inches high was filled to overflowing with hail and water. The thunder seemed to come first from east or southeast, then from south, then from west, and finally it was directly overhead. About the time when the hail was heaviest he saw ball lightning, "a ball of fire about the size of a football", pass over the house, under a great stone archway and away between some trees, with a tremendous crack, "a swishing noise" and leaving behind it a smell of burning.

At Stonehouse the fall for 24 hours ending 9 a.m. on the 12th was 3·96 inches, of which 3 inches fell between 4 p.m. and 9 p.m. on the 11th; the most intense precipitation was between 4 p.m. and 6 p.m. and included a heavy fall of ice hail, worst between 5 p.m. and 6 p.m.

The fall recorded at Glassford Filters was 3·18 inches and the rain there lasted from 4.20 p.m. to 10 p.m., being heaviest from 4.30 p.m. to 6.30 p.m. when about 2·5 inches fell. The Filter Keeper, Mr. John Lammie, and others at Glassford saw the waterspout for about a quarter of an hour and were able to confirm its position as being on the same bearing as Loudoun Hill. Its end was as described by Mr. Kirton of Dungavel. Mr. Lammie noted that the wind direction remained easterly throughout the storm. Thunder started in the southeast about 3 p.m., but the sun was still shining at Glassford Filters when the waterspout was first in evidence. The hail was heaviest from 5 p.m. to 6 p.m. Mr. Lammie gave it as his view that the maximum precipitation occurred somewhere in the gathering grounds of Muir Burn and Priest Burn, i.e. to the east side of East Overton House.

Mr. Hugh F. Dewar, Press Photographer, of Lamb Street, Hamilton, was also able to supply a description and the excellent photographs shown in Figures 2 and 3. He was talking to Sir Harry Lauder at a window in Lauder Hall (about a mile west of Strathaven) when the latter drew his attention to "a remarkable thing in the sky, coming down from a dark cloud." A thunderstorm was going on at the time. Mr. Dewar ran out to the front door with his camera and exposed two plates from that position looking up the Avon Valley towards Loudoun Hill in a southwesterly direction. The waterspout, he said, seemed to be hanging over the Strathaven–Darvel Road, which hereabout for a length of three miles points roughly towards Loudoun Hill. The photographs were taken about 4.15 p.m. at an interval of about two minutes on a Barnet Presto Plate, stop F8 at 1/50 sec.

At Glengavel the rain started at 5.10 p.m. and amounted to 1·20 inches. At Kype Reservoir the fall amounted to 1·03 inches,



Copyright : Hugh F. Dewar

FIG. 2.—WATERSPOUT, SOUTHWEST SCOTLAND, AUG. 11TH, 1938.

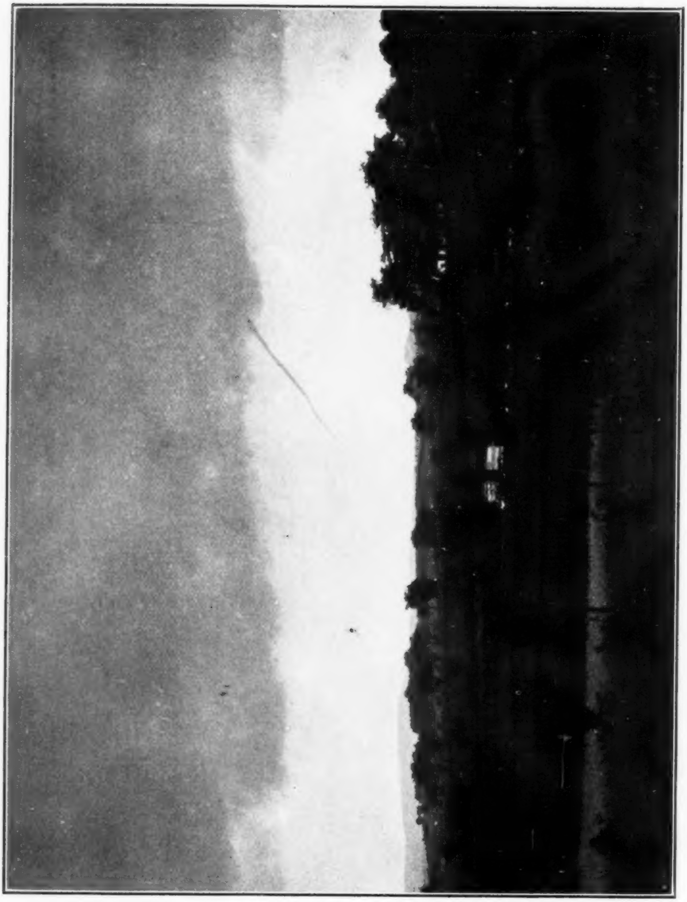


FIG. 3.—WATERSPOUT, SOUTHWEST SCOTLAND, AUG. 11TH, 1938 (ABOUT 2 MINUTES LATER THAN IN FIG. 2).

including very large hailstones for ten minutes. There was also ball and fork lightning. With the exception of an estimated value of 1·60 inches for Auchtyfardle (where rain is not measured every day), and 1·80 inches at Muirkirk, other falls in the surrounding area, though heavy, were mostly under an inch. The approximate distribution is shown by isohyets on the map. (Figure 1).

The synoptic chart for 13h. (2 p.m. Summer Time) on August 11th, as drawn at the meteorological station at Abbotsinch, shows a small shallow low over southwest Scotland and the Solway. It occupied the " col " between the major features of high pressures over the north Atlantic and Scandinavia, a low pressure over Iceland and wide shallow lows extending from England southeastwards over the continent. On the southwest Scottish coast winds were light northwesterly ; on the east coast and at Eskdalemuir and Abbotsinch they were easterly, also at Stonehouse and Glassford Filters. The boundary between northwesterly and easterly winds must, initially, have run approximately northwest to southeast through or to westward of Strathaven, and in fact the waterspout must have been lying in or very close to the surface of discontinuity. By about 7 p.m. the wind at Newmains, Douglas, had become northwest. No other record of the time of change in the Lanark area is available. At Edinburgh the change took place at 8 p.m. Summer Time. According to upper air observations at Aldergrove and Montrose the northwesterly current from the 900 mb. to the 700 mb. level was on the average some 4° F. warmer than the easterly one.

From 5,000 feet upwards, both currents showed rather steep lapse rates—somewhat steeper than the August normal—with considerable instability if surface temperatures should be raised—as they were by the day's insolation—to the order of 75° to 80° F. In these circumstances thunderstorms were to be expected. That phenomenal development took place in the Strathaven district must be attributed to coincidence with other favourable factors.

The Fourteenth Conference of the International Federation for Documentation

The International Federation for Documentation (formerly the International Institute of Bibliography) met at Oxford from September 21st to 25th, and was joined on the last two days by the Association of Special Libraries and Information Bureaux. Documentation is concerned with the rapid and concise supply of any information which may be required, and its importance to scientific and technical workers may be judged from the subjects discussed. These included : the making of abstracts from periodical literature, indexing systems, the practical use of bibliographies, photographic and " micro-film " methods of circulating information, systems of cataloguing and indexing, the organisation of information services, and library co-operation.

The Conference was especially concerned with the problem presented by the ever-growing volume of printed material, especially in the form of scientific and technical periodicals. It is almost impossible to keep track of all the literature of any one subject, while language difficulties make foreign works closed books to many readers. No one worker can possibly read even a tenth of that which refers to his own subject, even if he has the gift of tongues. During the discussions reference was made again and again to researches which had been repeated, sometimes at considerable cost of time and money, because the investigator did not know that they had already been carried out by some one else who had published his results. One investigation quoted had actually been repeated seven times. All this unnecessary work represents a great waste of effort which can be avoided by the proper use of bibliographies. One large research association has made it a rule not to authorise any proposed investigation until a bibliography of the subject has been compiled, in order to guard against such duplication. Bibliographies and, still more, abstracts are of very great value in supplying essential data and fruitful ideas and nearly every large technical organisation now has its own special information service.

The need for bibliographies and abstracts having arisen, it has been met to some extent, but in a haphazard and wasteful manner. In some subjects sufficient effort is put into abstracting to cover the literature twice, yet many important papers are missed. International co-operation is needed, such as that initiated so successfully in meteorology by the Bibliography Commission of the International Meteorological Organization, but applied to all knowledge instead of to separate sciences. Dr. Bradford has proposed that each country should have a central clearing house for abstracts, and if the present spate of publications continues unchecked, some such arrangement will soon become urgently necessary. In science as in economics we are threatened with a breakdown in the distribution of the products of labour.

The long-standing battle between the exponents of numerical and of alphabetical classifications was continued, but advantage inclines more and more to the former. Other problems usefully discussed included the transliteration of names from one language into another and the rules of alphabetical arrangement.

Great interest was aroused in a paper by Prof. A. F. C. Pollard on "The mobilization of knowledge and the 'Permanent World Encyclopaedia' of Mr. H. G. Wells." The great objection to even the finest encyclopaedias, such as the *Britannica*, is that they are out of date almost as soon as they are published. The ideal solution would be a "loose-leaf" form to which new knowledge can be added as soon as it is published in research periodicals. This form of publication already exists in a few professions, notably medicine and law, and a more ambitious project is in hand in France. The movement will undoubtedly spread, and though the difficulties would be

very great, modern methods of printing have brought it within the bounds of possibility, but the basis on which it must rest is scientific bibliography. Mr. Wells himself took part in the discussion and was warmly applauded.

Socially the Conference was highly successful and afforded an excellent opportunity for comparing ideas and methods in different countries, which is not the least valuable part of such meetings, and there was on view an exhibition of British abstracts, bibliographies and other publications in which the Universal Decimal Classification is employed. Meteorology was represented by *Geophysical Memoirs, Professional Notes* and the *Quarterly Journal, Memoirs* and *Bibliography* of the Royal Meteorological Society, making quite a good show.

On Monday, September 26th, the Conference re-assembled at the Science Museum, London, to witness an exhibition of microphotographic apparatus and to discuss problems of documentary cinematography.

OFFICIAL NOTICE

Discussions at the Meteorological Office

The series of meetings for the discussion of recent contributions to meteorological literature, especially in foreign and colonial journals, has been resumed at the Meteorological Office, South Kensington.

Meetings are held on alternate Mondays at 5 p.m. (tea is available from 4.30 p.m.) and the Director of the Meteorological Office wishes it to be known that visitors are welcomed at these meetings.

The discussions in October were as follows :—

October 17th, 1938. *The colloidal-meteorological processes in the formation of rain.* By W. Findeisen. *Met. Zs.*, **55**, 1938, pp. 121–133. (In German). *Opener*, Sir George Simpson.

October 31st, 1938. (1) *A method for the investigation of upper-air phenomena and its application to radio-meteorography.* By H. Diamond, W. S. Hinman and F. W. Dunmore, Washington, *J. Res. Nat. Bur. Stand.*, **20**, 1938, pp. 369–392. (2) *The determination of the meteorological conditions of the atmosphere by the use of radio-sounding balloons.* By H. A. Thomas. *London, Proc. R. Soc.*, **167** (A), 1938, pp. 227–250. *Opener*, Mr. G. J. W. Oddie.

The subjects for discussion at subsequent meetings are :—

November 14th, 1938. *Thermodynamic transformations in the stratosphere and iridescent clouds.* By J. Jaumotte. *Bruxelles, Mem. Inst. R. Met. Belge*, **5**, 1936, pp. 43. (In French). *Opener*, Mr. N. Bradbury.

November 28th, 1938. (1) *Fronts and boundary surfaces in theory and practice.* By P. Raethjen. *A. Hydr*, **66**, 1938, pp. 97–104. (In German). (2) *How weather is caused and how to foretell*

it. By T. Bergeron. Ymer, Stockholm, 1937, pp. 199–229. (In Swedish). *Opener,* Mr. H. H. Lamb.

December 12th, 1938. (1) *Contributions to the dynamics of rainshowers.* By G. A. Suckstorff. Göttingen, *Nach. Phys. Astr. Geoph. Tech.*, **2**, 1936, pp. 9–49. (In German). (2) *On the temperature conditions and direction of travel of a rainshower.* By W. Schwerdtfeger. *Z.a.Met.*, **54**, 1937, pp. 76–85. (In German). *Opener,* Mr. G. R. R. Benwell.

The dates for the subsequent meetings are as follows:— January 16th and 30th, February 13th and 27th, and March 13th, 1939.

OFFICIAL PUBLICATION

Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Air Council for the year ended March 31st, 1938

The year under review has been one of progress towards providing the greatly increased meteorological services required to meet the ever-growing needs of the Royal Air Force and Civil Aviation. Steady recruitment of staff to both officer and assistant grades has continued and new meteorological stations on service and civil aerodromes have been opened as trained staff have become available.

A new system of communication with meteorological stations well distributed over the country was initiated during the year by the installation of direct teleprinter connexions between these stations and Headquarters, and work is proceeding on a large extension of this method of communication.

For the trans-Atlantic flights in July, 1937 the meteorological station at the Shannon Airport (operated on an agency basis by the Meteorological Office for the Government of Eire) and the meteorological station at Botwood (operated by the Meteorological Service of Canada on behalf of the Government of Newfoundland) supplied full meteorological information both prior to and during the flights. Subsequent to the flights conferences were held at Toronto and Dublin to review the meteorological organization and, so far as possible, to perfect the arrangements for the exchange and supply of meteorological information.

The Office is collaborating with the National Physical Laboratory in investigating a method of measuring upper air conditions by radio instruments carried on unmanned balloons. Two types of instrument are being developed, one for measurement of wind and the other for the determination of pressure and temperature, in the upper atmosphere.

On behalf of the Committee on Locust Control (Economic Advisory Council) the Office is conducting an investigation of the climatic conditions in Africa for the years 1925 to 1936, during which there were serious outbreaks of locust swarms.

Correspondence

To the Editor, *Meteorological Magazine*

August Frosts in Southern England

In connection with Mr. Donald L. Champion's report* of a grass minimum temperature of 29·3° F. at Goff's Oak, Herts, during the night of August 20th–21st, 1938, it may be of interest to record the occurrence on that occasion of the earliest "autumn" frost yet registered in the Stevenson screen at the Rickmansworth valley climatological station, to which Mr. Champion refers in his letter. By the standard thermometer the minimum reading there was 30·0° F. According to the trace of the thermograph, the temperature underpassed 40° F. at 22h. (G.M.T.) on August 20th, reached the freezing-point by 3h. 45m. on August 21st, and then sank slowly to 30·5° F. by 5h., a few minutes after sunrise. There was no apparent change until 6h. 15m., when the valley emerged from the shadow of the eastern hills and a rapid increase of warmth set in: 40° F. was attained by 7h. 45m., 50° F. by 8h. 50m., and 60° F. by 10h. 10m. The minimum at 1 inch above short grass was 23° F.

Hitherto, the earliest date for an "autumn" screen frost since observations were begun at the station 9½ years ago was August 26th, 1934 (31·9° F.). It is rare for *any* calendar month to pass without radiation frost (32·0° F. or lower) on at least one night in this Hertfordshire valley. From May, 1929 to September, 1938, there were only two such instances, the Augusts of 1930 and 1932, with extreme grass minima of 32·2° F. and 36·3° F. respectively. The period of the summer during which the standard thermometer 4 feet above the ground has not yet been below 32·0° F. at the Rickmansworth station now extends from July 1st to August 20th, 51 days. Having regard to the fact that 32·2° F. was recorded on July 31st, 1935, 34·6° F. on July 22nd, 1936, and 36·1° F. on August 10th, 1931, one can hardly doubt that over a long series of years in this particular corner of southern England there would be no gap at all between the last screen frost of "spring" and the first screen frost of "autumn," in whatever way the duration of these seasons may be defined.

E. L. HAWKE.

Ivinglea, Dagnall, Bucks, September 30th, 1938.

Snow in July at Sea Level

Mr. Robson's report† of genuine snow on the Lancashire and Cheshire coast on July 9th, 1938 is, of course, much more remarkable than it would have been on the original date given, June 9th. Occurrences

* In the September issue of this Magazine.
† *See* pages 208 and 240.

of summer snow at sea-level in England should always be carefully described in the manner done by Mr. Robson, because most so called snow at that season is open to the suspicion of being fundamentally soft hail. The suspicion is not weakened from the stupid habit the newspapers have got into of announcing a foot or two of "snow" after every severe summer thunderstorm with drifting hail. The popular confusion between snow and hail would not matter so much if the meteorological associations of the two species of frozen precipitation were not so entirely different.

Mr. Robson, unfortunately, has not stated the air temperature at the time the snow squall passed, which would have been of particular interest. We know that in mid-winter snow practically never falls with the temperature over 35° F., whereas in spring, from March onward, showers of snow frequently fall when it is over 40° F. The reason should be obvious: in winter, temperature over 40° F. signifies a warm current which can only carry rain, whereas in spring it may be due to shallow surface sun-heating in a bitterly cold polar current. During the night of July 10th–11th, 1888, snow is reported to have fallen around London, though the air temperature at Brixton reported in the *Daily Weather Report* did not drop below 44° F. The wintry squalls that crossed England on that date appear to have brought precipitation which varied from place to place between real snow, granular snow and soft hail; but records are scanty and it is not easy at this distance of time to find out in detail what really did happen.

L. C. W. BONACINA.

13, Christchurch Hill, Hampstead, N.W.3, October 21st, 1938.

The Great Gale of June 1st, 1938

When I was in charge of the South Farnborough Meteorological Office during the war there was a very severe gale from the south. There was a deposit on the windows of the Office which faced south and this deposit tasted distinctly salt.

The discolouration of foliage due to the gale of June 1st extended as far as here, 17 miles from the open sea, and even further for I saw traces of it as far inland as Newbury and Odiham, about 48 and 32 miles from the open sea respectively.

Summer gales from seaward do not ordinarily turn foliage brown, and it would be interesting to know why they should do so on rather rare occasions. Can it be that for this to happen there must be a period when the gale is strong but there is no rain, so that salt is blown inland and deposited on trees and not washed off again? Possibly there may be records from hyetographs and anemographs which would throw some light on the question.

C. J. P. CAVE.

Stoner Hill, Petersfield, October 30, 1938

Experiments with No-lift Balloons

The effect mentioned by Mr. Dines (in the October issue of this Magazine) must tend to introduce a systematic error, which could be measured only by statistical investigation of a much larger number of occasions.

The actual amount of superheating which might be present on a particular occasion is difficult to estimate. In bright sunshine the no-lift balloon ought to show a good example of greenhouse effect in so far as the isolating of a small mass of gas from the general convection is concerned. In the absence of any available literature dealing with the subject, assume that about 10° superheating occurred on the brighter days, giving a rise of about 100 feet/min. according to the figures calculated by Mr. Dines. If the rising velocities introduced had been appreciably greater it seems likely that some effect would have been noted in the working-up of the results, particularly in the comparison of the results as associated with stratiform and cumuliform clouds, but no definite conclusion was reached in this respect. Considering all the days on which experiments were made, the amounts of bright sunshine recorded were on the average little different from the seasonal averages, and it appears that the days can be regarded as a fair sample; the inference is that the errors introduced by superheating were not in general larger than the other possible experimental errors.

While there is some support for this view in the consideration that the order of magnitude of the vertical currents measured at Leuchars was comparable with that found in experiments made by different methods in more or less similar exposures, the fact remains that the assumption that the "no-lift" condition is maintained on occasions of strong insolation may involve considerable errors.

S. T. A. Mirrlees.

Meteorological Office, Leuchars, Fife, October 17th, 1938.

Blackening of Foliage by Gales

I have read your note on page 241 of the *Meteorological Magazine*, referring to the effect of the June gale.

I am 10 or 12 miles inland and experienced similar effects earlier this year (I think—though I cannot trace it in my diary). The leaves were all blackened and torn, and such things as rose petals suffered badly.

On the morning of October 4th this year, however, we had a gale ten times worse in its effects. Its severity may be judged by the number of trees down in the neighbourhood (500, I believe, in Knowsley Park); but the main effect was the blackening and shrivelling and tearing of all the leaves on the western sides of the trees and bushes. The tearing took place at the time, but the blackening only became evident a few hours later. Such flowers as dahlias were completely destroyed on the western side of the plant,

but the more easterly half has since recovered. In places where there was some slight protection to act as a wind brake, there was slightly less blackening noticeable.

Within a few days all the affected leaves on the trees (*i.e.*, all except those well up on the east branches) had shrivelled up and fallen off in light breezes although they had not begun to change colour at the time of the gale.

Yesterday I was out picking blackberries. The bushes were entirely denuded of leaves and berries (though the skeletons of the leaves were often still on the bushes !) on the west side of the hedges, but on the other side the berries were many and good, and the leaves green, even on the same plant. It was raining practically continuously throughout the storm and again very soon afterwards.

In any westerly gale salt is deposited on my windows, 12 or 15 miles from the sea. My own opinion certainly was that the damage was caused by the destructive force of the wind on the wet and sodden leaves and plants, and not by the action of the salt, but on the other hand in travelling about I couldn't help observing that the effects on plant life were steadily less severe the further one got from this part of the country where the wind had come straight off the sea.

The minimum temperature, somewhere near the height of the gale was 47°, thus belying a popular impression here that frost was partly responsible for the unusual damage.

I hope this gives you some of the information you require.

W. H. PILKINGTON.

Windle Hall, St. Helens, Lancashire, October 24th, 1938.

[*Many letters are unavoidably held over owing to exceptional pressure on our space.*—EDITOR.]

NOTES AND QUERIES

The Hurricane of September 21st, 1938 in New England

Mr. Caleb Mills Saville, Chief Engineer of the Water Bureau of the Metropolitan District of Hartford County, Connecticut, has forwarded details of the severe storm which occurred in the east of U.S.A. on September 21st. A reference to the damage caused by this storm was given on p. 252. The Connecticut River rose to the second highest level ever recorded, being about 2 feet lower than that of March, 1936. The damage by flooding in 1938 was fortunately less than that of 1936, and this must be attributed in part to the precautions taken since 1936. The flood of 1938 was due mainly to widespread and persistent rains, more especially over the lower portions of the drainage area, whereas that of 1936 was caused by heavy rain on the upper regions augmented by the melting of snow and ice, which had occurred previously. The rainfall amounts recorded at West Hartford Reservoir for the five days September 18th to 22nd,

1938, were ·52, 2·10, 1·55, 4·92 and 1·07 inches respectively, a total of 10·16 inches. The maximum rainfall in one hour was 1·07 inches; in six hours 2·57 inches; in 24 hours 5·11 inches; in 48 hours 7·18 inches, and in 72 hours 9·04 inches.

The heavy rain was associated with the passage of a low pressure system in a northerly direction. It was centred well to the east of Florida on the morning of the 20th, off the coast of North Carolina at 9h. on the 21st and near Ottawa at 9h. on the 22nd. The barogram at Hartford showed a remarkable fall on the 21st, *viz.*, 29·41 inches (996 mb.) at 11h., 29·25 inches at 13h., 28·92 inches at 14h., 28·28 inches at 15h. and 28·00 inches (948 mb.) at 15h. 30m. At 19h. the pressure had risen to 29·05 inches. It is reported that at the centre of the storm the barometric reading was 26·00 inches (880 mb.).

In some cases the wind velocity was estimated to exceed 100 mi/hr. and great damage was caused to property in Hartford by fallen trees. Remarkable damage also occurred along the shore, " both on account of the wind and its effect on the sea, which was similar to a tidal wave." Whole areas of beach development were wiped out, in one place as many as 400 cottages being destroyed. New coast-lines were also formed, in some cases the former character of the beaches being entirely obliterated.

J. G.

Auroral Notes

The total number of aurorae seen in Scotland between August 1937 and May 1938, was 108, the highest total since 1929–30, and the figures for the first three months of the current season are also above the average.

August.—Aurora was observed from various places, chiefly in Scotland, on nine nights during August, an exceptionally high figure for that month. One display was visible as far south as Holyhead where, late on the 3rd, one white ray, which moved eastwards before disappearing, reached an elevation of 53° at 23h. 50m. Another display occurred on the following evening and was best seen by Mr. H. H. Lamb from Montrose where it appeared in the southern sky shortly after 23h. The most striking feature was the regular variation of intensity, with period two or three minutes, and the changes of colouring, gold, crimson, blue and vivid green being observed.

September.—No aurora was seen in September until the 13th, but during the remainder of the month it was reported on 13 nights and was seen from Lerwick on all but one of the nights when cloud permitted observation. The display of the 14th was visible over a wide area, and detailed accounts have been received from Mr. J. R. Sandison of Leuchars and Mr. H. E. Heaton of Abbotsinch, Mr. R. Forbes-Bentley of Holyhead and Mr. Lamb. The latter part of the

display was also seen by the writer, who secured a photograph which does not, however, show more than a diffuse glow.

At 20h. 15m. a long homogeneous quiet arc was present and ray activity soon commenced in the west, most of the rays moving slowly eastwards before fading, although some moved in the opposite direction. Similar phenomena continued at intervals throughout the evening but the rays never appeared to extend any considerable distance from the arc.

Some rays in the northwest, as seen from Edinburgh at 22h. 15m., shot up from the horizon towards the arc and apparently originated in a second arc which slowly rose above the horizon and eventually merged into that already present. This second arc was narrow, having a uniform width of 3° and was also remarkable for two bright patches at azimuth 327° and 354° as seen from Leuchars. Further rays, moving eastward, appeared after the arcs had united but the aurora became quiescent and faded after 23h., although it was still visible from Abbotsinch at 23h. 30m. and from more northern stations until 2h.

The colouration was mainly greenish white throughout but some of the rays had a golden hue in their lower portions.

It has not been found possible to compute from the observations the exact height or position of the auroral arc, but it was probably at about 100 km. from the earth's surface and extended from Norway across Shetland to mid-Atlantic.

As is usually the case during active aurorae a severe magnetic storm was recorded. It began at 15h. 30m. on the 14th and continued throughout the night and following day. Between 16h. on the 14th and 3h. on the 15th the range of variation of the three components of the earth's magnetic field at Lerwick were:

Horizontal component	$1{,}526\gamma$	($\cdot 015$ C.G.S. units)
Vertical ,,	843γ	($\cdot 008$ C.G.S. ,,)
Declination... ...	$2^\circ\ 0'\cdot 8$	

There was also interference with short wave wireless reception at Abbotsinch, especially on the afternoon of the 14th and 15th.

The displays of the 26th and 30th were also active and extended into the southern sky at Lerwick; cloud prevented their observation from more southerly stations. On the 30th every type of aurora was seen, from quiet arcs to coronae; the red patches which were so prominent in the display of January 25th to 26th also occurred.

October.—October is the month in which aurora occurs most frequently in these latitudes and this year it was seen on 15 nights, one more than the average number. As in September there were comparatively few displays in the first half of the month. The brightest and most active displays were those of the 7th and 26th; on the 7th draperies and coronal types predominated and persistent flaming aurora was the chief feature on the 26th.

F. E. DIXON.

Dr. WILLIS RAY GREGG

Dr. Willis Gregg, Chief of the United States Weather Bureau, died on September 14th, 1938. He was born in Phoenix, N.Y., on January 4th, 1880. Dr. Gregg entered the U.S. Weather Bureau as an assistant observer in 1904, a year after having taken his B.A. degree at Cornell University. For several years he was stationed at the Mt. Weather Observatory where frequent upper air soundings were conducted, and it was there that his interest in aerology became deep-seated. When the Government later established a network of sounding stations, he soon took charge of the work and was the first to make a thorough study of the upper air conditions over a large section of the United States. As head of the division of aerology, to which he was appointed in 1917, his unique knowledge of the upper atmosphere together with the rapid development of aviation placed him in a position of singular responsibility and authority. In 1919 he served as a special meteorological adviser for the trans-Atlantic flight of NC planes (USN) at Trepassey, Newfoundland, and, in July of the same year, he served in the same capacity for the British dirigible R.34, at Mineola, N.Y. He was appointed, in 1922, to the National Advisory Committee for Aeronautics, meteorological sub-committee. Under his direction, the aerological division of the Weather Bureau expanded to such an extent as to become the largest in the service. He relinquished this post to become Chief of the Weather Bureau in 1934.

As head of this complex and important organization, he put in effect the recommendations of the Science Advisory Board, in the formulation of which his advice was frequently sought. The number of airplane sounding stations was increased from 6 to 20–25. Frequent maps were inaugurated for the entire country and for all types of activities and the method of air-mass analysis was introduced as a valuable supplement to the existing method of daily weather forecasting. In the development of a weather service for aeronautics, he attained a high and widely appreciated measure of success.

It was characteristic of Dr. Gregg that he obtained the co-operation of many independent organizations in the prosecution of meteorological research in his own country and abroad. As an active officer of the International Meteorological Organization, he was instrumental in bringing about greater co-operation between the United States Weather Bureau and meteorological services in other parts of the world.

Dr. Gregg was the author of a very valuable work on aeronautical meteorology and the co-author of two books on meteorology, besides contributing to various periodicals at home and abroad. He was a member of many distinguished scientific bodies, often serving in a high capacity. Norwich University conferred upon him, in 1937, the honorary degree of Doctor of Science.

I. I. Schell.
(Late U.S. Dept. of Agriculture.)

New Climatological Stations in Scotland

New climatological stations, approved by the Meteorological Office, have recently been set up by Mr. G. King, Burgh Surveyor, Lossiemouth, Morayshire, by Mr. J. Edwards Moss at Strathy (Bowside Lodge), Sutherland, and by the Galloway Water Power Co. at their Tongland Power Station, Kirkcudbright. The latter company had already a climatological station at Glenlee where observations commenced on January 1st, 1937. In view of the sparseness of stations in the northern mainland districts of Scotland, the establishment of the new station at Strathy is particularly to be welcomed.

REVIEW

The Weather of India. By C. W. B. Normand, C.I.E., M.A., D.Sc. Reprinted from " An outline of the field sciences in India." Calcutta, Ind. Sci. Congr. Ass., 1937. Pp. 16.

This is a short but very readable account of the meteorological conditions prevailing in the different parts of India through the year and its illustrations are particularly vivid and helpful. We note with interest that some of the winter depressions after leaving north India have been traced into China, and are curious enough to study the chart of mean annual rainfall to see how far recent records of hill stations on the western Ghats and in south Burma have produced rivals to Cherrapunji. The chart of cyclone tracks shows how small a vertical component of the rotation of the earth is necessary for their production ; one cyclone is shown as forming in lat. 6°N. and many begin to the south of lat. 10'N. G. T. Walker.

The Weather of October, 1938

Mean pressure for the month exceeded 1020 mb. over the eastern Atlantic west of Spain, reaching 1024 mb. near the Azores, which was 5 mb. above the normal. Northwards from the Azores the mean pressure decreased rapidly to below 990 mb. in Iceland, the mean of 989 mb. at Reykjavik being 15 mb. below normal. Over Greenland, the British Isles and Scandinavia pressure was also below normal, the deficit reaching 10 mb. at Myggbukta and Lerwick ; elsewhere in Europe pressure was near the normal. No data were received from Russia or Siberia. In North America, mean pressure was near the normal over the United States, being above 1015 mb. everywhere and exceeding 1020 mb. at Nashville ; it decreased to below 1005 mb. over Alaska where it was 5 mb. below normal.

Temperature was generally slightly above normal ; the excess reached 7° to 9° F. in northern Scandinavia and 9° to 12° F. in north-west Canada. Mean temperature was over 80° F. in Anglo-Egyptian Sudan and reached nearly 90° F. at Khartoum ; it was slightly over 70° F. on the northern coast of Africa, over 60° F. in southern Europe, over 50° in France, much of central Europe, Ireland and most of

England, and it decreased to 40° F. in the extreme north of Scandinavia. In North America the mean temperature decreased northwards from over 70° F. in the extreme south of the United States to below 30° F. in the extreme north of Canada and Alaska.

The rainfall was rather variable. It was below normal in Italy, France and southern England, but it was excessive in parts of Ireland, Scotland, Sweden and the Baltic States, where in many places the fall for the month was double the average. In North America, with local exceptions, the amounts were generally below normal expecially in the Gulf States.

Over the British Isles the weather of the month was notable for the excessive rainfall in the west and north and the widespread, severe gales of the 3rd to 4th. Rainfall exceeded twice the average over large parts of Scotland, Ireland, north-west England and locally in north Wales; at Birr Castle the total equalled that of October, 1870, the previous highest there for October. Less than the average occurred at numerous places south-east of a line drawn roughly from the Humber to south Devon. From information at present available it appears that sunshine was below the average in most of Ireland and parts of north and west Scotland and of western England, but exceeded the average on the whole in the eastern half of Great Britain and the Midlands. Mean temperature somewhat exceeded the average generally but was about or a little below the average in the south-east.

Between the 2nd and 5th depressions moved north-east over Scotland; very unsettled weather prevailed with gales and heavy rain at times and local thunderstorms. The disturbance which crossed Scotland during the early hours of the 4th was very intense and caused widespread and severe gales; a wind speed of 104 mi/hr. was registered in a gust at Pembroke; considerable damage occurred and some loss of life. From the 6th to the 18th the tracks of the main depressions lay to the northward of Scotland, while associated secondary depressions passed across the British Isles. Gales were reported locally in the west and north on most days, while rain occurred frequently and was heavy at times. Local thunderstorms occurred between the 4th and 7th and on the 10th and 12th. Large daily falls of rain were numerous, particularly on the 2nd, 3rd, 5th, 6th, 8th and 12th; among the heaviest were 3·20 in. at New Dungeon Ghyll, Westmorland, and 2·99 in. at Borrowdale, Cumberland, on the 2nd; 3·86 in. at Borrowdale and 3·60 in. at New Dungeon Ghyll on the 3rd; 3·49 in. at Borrowdale on the 6th; 2·91 in. at Borrowdale and 2·90 in. at Blaenau Festiniog, Merioneth on the 8th, and 3·80 in. at Blaenau Festiniog, 2·89 in. at Ystalyfera, Glamorganshire, and 2·21 in. at Oughtershaw, Yorkshire, on the 12th.

On the 19th and 20th a wedge of high pressure moved eastward over the country and subsequently an anticyclone was established over the Baltic region; over most of England fair weather prevailed,

apart from fog, until the 25th. In the west and north, however, conditions were mainly unsettled. A good deal of fog developed in England on the 20th and from the 22nd to 25th. Rainfall was rather heavy in Ireland on the 21st. Sharp frost occurred locally in south-east and east England on the 25th; a screen minimum of 25° F. was registered at Rothamsted and Tunbridge Wells.

On the 26th a depression near the Faeroes moved south-south-east giving rain in most parts on the 26th and 27th, and on the 30th and 31st secondary depressions associated with a disturbance near Iceland moved eastward over the country and caused further rain which was heavy locally on the 31st.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway ..	81	+4	Chester ..	102	+11
Aberdeen ...	110	+16	Ross-on-Wye	101	+2
Dublin	100	+2	Falmouth ..	121	+8
Birr Castle ..	68	−22	Gorleston ..	126	+11
Valentia ..	77	−13	Kew.. ..	111	+15

Kew temperature, mean, 51·1°F.: diff. from average, −0·5°F.

Miscellaneous Notes on Weather Abroad

Severe storms swept across France and the Low Countries on the 4th October causing much damage to trees and telegraph poles and disorganizing shipping in the Channel. A hurricane, accompanied by low temperatures, was reported from the Black Sea area on the 21st. Low lying parts of the coast were inundated and snow fell in the mountains in Bulgaria, three persons dying of cold. A tornado struck Limassol, Cyprus on the 23rd, and telephone and lighting services were interrupted. Snow fell in the Alps down to 4,000 ft. on the 27th, and many passes were closed to vehicles. Heavy floods following storm rains were reported from western India in the early part of the month, 15 persons were drowned and several houses collapsed in the Bombay suburbs. 500 people were killed and many hundreds injured during typhoons which swept across Japan on the 15th and 21st. The Osumi Peninsula and the lower parts of Tokyo were flooded, over 25,000 houses being inundated, and all sailings from Yokohama were suspended. High temperatures were recorded in New York in the middle of the month, 86° F. being reported on the 17th: at the same time the New England coast experienced thick fog which stopped all sea and air travel. Five people lost their lives and many were injured in floods which followed a rainstorm in Grenada on the 29th. Valuable rains fell in the pastural and agricultural districts of South Australia during the latter part of the month, breaking the drought which had held for many months and thus saving the harvest. (*The Times*—various dates.)

ERRATA

Climatological Tables, 1938

Kaduna, Pressure.	Jan.	*For*	1012·2	*read*	1011·6.
	Feb.	„	1012·2	„	1011·5.
	Mar.	„	1009·6	„	1008·9.

Daily Readings at Kew Observatory, October, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain	Sun	Remarks
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1016·1	WNW. 3	49	61	56	0·03	3·4	ir_0–r 7h.–9h.
2	1002·3	SSW. 3	49	57	90	0·17	1·2	ir_0 5h.–8h., r^0 10h.–[14h.
3	1005·3	SW. 5	44	58	67	0·40	4·5	r–r_0 16h.–23h.
4	996·7	WSW. 5	51	60	48	0·02	6·6	r_0 7h. & 19h–20h.
5	998·5	SSW. 3	51	55	87	0·13	0·3	r_0 8h., r–r_0 12h.–16h.
6	1012·5	WSW. 3	46	58	51	—	7·2	
7	1000·4	W. 4	50	58	87	0·13	0·1	d_0–r 8h.–14h.
8	1016·7	SW. 3	48	59	63	0·04	3·8	d_0–r 15h.–18h.
9	1002·1	SW. 4	52	64	68	0·22	0·1	r–r_0 3h.–9h.
10	1010·7	SW. 3	47	58	66	—	2·1	
11	1017·9	SW. 4	43	59	59	—	5·9	
12	1022·3	SW. 4	46	60	69	0·04	1·6	r_0 17h.–18h. & 23h.
13	1014·5	SW. 5	55	61	88	0·17	0·0	ir_0–r 5h.–10h.
14	1021·1	W. 3	51	60	54	—	8·0	
15	1021·3	SSW. 3	46	58	67	trace	4·7	ir_0 20h.
16	1011·8	SSW. 3	49	61	86	0·28	0·0	ir_0–r 3h.–9h., d_0 16h.
17	1012·1	SSW. 4	50	61	66	—	7·5	
18	1008·4	SSW. 3	52	60	71	0·08	3·8	ir_0–r 2h.–4h., d_0 13h.
19	1022·1	W. 3	50	57	53	—	6·6	f 21h.–24h.
20	1027·4	S. 2	39	59	76	—	4·4	F till 10h.
21	1023·1	SE. 3	43	59	49	—	8·7	m 9h.
22	1011·2	SSE. 3	42	54	74	—	7·0	f–F 20h.–24h.
23	1014·1	E. 2	41	56	71	—	4·5	F–f 0h.–12h., F 21h.–[24h.
24	1019·5	W. 1	34	51	88	—	1·9	F–f 0h.–24h.
25	1013·0	W. 1	32	49	94	—	1·7	F–f 0h.–24h.
26	1010·7	NW. 3	36	53	54	0·22	4·6	r–r_0 2h.–5h., 18h.–23h.
27	1006·0	NW. 2	38	48	67	0·06	4·0	r_0 3h.–5h. & 22h.–24h.
28	1015·1	N. 3	45	53	62	—	3·7	f 21h.–24h.
29	1014·2	Calm	39	53	67	—	2·7	f 9h. & 16h.–17h.
30	1007·7	S. 2	44	56	89	0·07	0·0	id_0–r 9h.–19h.
31	1015·4	SW. 3	39	53	72	—	0·3	
*	1012·6	—	45	57	70	2·06	3·6	*Means or Totals.

General Rainfall for October, 1938

England and Wales	126	per cent of the average 1881–1915.
Scotland	186	
Ireland	193	
British Isles ...	154	

Rainfall : October, 1938 : England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square..........	2·72	103	*War* .	Birminghm, Edgbaston	2·67	96
Sur .	Reigate, Wray Pk. Rd..	3·46	104	*Leics* .	Thornton Reservoir ...	2·52	90
Kent .	Tenterden, Ashenden...	3·62	104	,, .	Belvoir Castle...........	2·07	77
,, .	Folkestone, I. Hospital.	3·35	...	*Rut* .	Ridlington	2·19	78
,, .	Margate, Cliftonville....	2·56	88	*Lincs* .	Boston, Skirbeck..........	2·25	82
,, .	Eden'bdg., Falconhurst	3·79	105	,, .	Cranwell Aerodrome...	1·91	67
Sus .	Compton, Compton Ho.	5·34	117	,, .	Skegness, Marine Gdns.	1·90	69
,, .	Patching Farm..........	4·05	102	,, .	Louth, Westgate..........	3·05	94
,, .	Eastbourne, Wil. Sq....	3·99	96	,, .	Brigg, Wrawby St.......	2·71	...
Hants .	Ventnor, Roy.Nat.Hos.	4·50	114	*Notts* .	Mansfield, Carr Bank...	3·18	105
,, .	Southampton,East Park	3·65	93	*Derby* .	Derby, The Arboretum	2·48	91
,, .	Ovington Rectory.......	3·70	91	,, .	Buxton, Terrace Slopes	7·53	153
,, .	Sherborne St. John......	3·87	110	*Ches* .	Bidston Obsy.............	4·01	123
Herts .	Royston,Therfield Rec.	2·67	98	*Lancs* .	Manchester, Whit. Pk.	6·15	186
Bucks .	Slough, Upton............	2·50	89	,, .	Stonyhurst College......	10·69	238
Oxf .	Oxford, Radcliffe.........	2·84	98	,, .	Southport, Bedford Pk.	6·93	196
N'hant	Wellingboro, Swanspool	2·68	106	,, .	Ulverston, Poaka Beck	10·81	195
,, .	Oundle	1·74	...	,, .	Lancaster, Greg Obsy.	9·53	232
Beds .	Woburn, Exptl. Farm...	2·88	108	,, .	Blackpool	7·19	193
Cam .	Cambridge, Bot. Gdns.	2·47	105	*Yorks* .	Wath-upon-Dearne......	2·89	104
,, .	March.......................	2·20	85	,, .	Wakefield,Clarence Pk.	3·54	123
Essex .	Chelmsford,County Gdns	2·55	104	,, .	Oughtershaw Hall.......	18·81	...
,, .	Lexden Hill House......	2·63	...	,, .	Wetherby, Ribston H..	...	...
Suff .	Haughley House..........	2·45	...	,, .	Hull, Pearson Park......	2·96	99
,, .	Rendlesham Hall........	3·19	123	,, .	Holme-on-Spalding......	3·47	116
,, .	Lowestoft Sec. School...	2·59	93	,, .	Felixkirk, Mt. St. John.	3·74	130
,, .	Bury St. Ed., WestleyH.	2·79	103	,, .	York, Museum............	3·15	117
Norf. .	Wells, Holkham Hall...	2·53	90	,, .	Pickering, Houndgate...	4·04	132
Wilts .	Porton, W.D. Exp'l. Stn	2·69	86	,, .	Scarborough...............	3·40	109
,, .	Bishops Cannings........	4·51	136	,, .	Middlesbrough............	3·08	103
Dor .	Weymouth, Westham.	3·40	93	,, .	Baldersdale, Hury Res.	8·37	210
,, .	Beaminster, East St....	5·01	113	*Durh* .	Ushaw College............	3·47	101
,, .	Shaftesbury	2·35	60	*Nor* .	Newcastle, Leazes Pk...	3·58	116
Devon .	Plymouth, The Hoe....	3·92	99	,, .	Bellingham, Highgreen	6·01	153
,, .	Holne, Church Pk. Cott.	9·20	139	,, .	Lilburn Tower Gdns....	5·22	141
,, .	Teignmouth, Den Gdns.	2·83	73	*Cumb* .	Carlisle, Scaleby Hall...	7·35	220
,, .	Cullompton	3·48	84	,, .	Borrowdale, Seathwaite	29·25	257
,, .	Sidmouth, U.D.C.........	2·81	...	,, .	Thirlmere, Dale Head H.	20·98	235
,, .	Barnstaple, N. Dev.Ath	5·04	111	,, .	Keswick, High Hill......	16·99	303
,, .	Dartm'r,Cranmere Pool	9·90	...	,, .	Ravenglass, The Grove	8·48	196
,, .	Okehampton, Uplands.	7·42	123	*West* .	Appleby, Castle Bank...	7·73	222
Corn .	Redruth, Trewirgie......	...	...	*Mon* .	Abergavenny, Larchf'd	4·21	100
,, .	Penzance, Morrab Gdns.	5·04	108	*Glam* .	Ystalyfera, Wern Ho....	13·00	189
,, .	St. Austell, Trevarna...	5·07	96	,, .	Treherbert, Tynywaun.	15·78	...
Soms .	Chewton Mendip.........	8·38	174	,, .	Cardiff, Penylan..........	8·15	172
,, .	Long Ashton.............	5·92	157	*Carm* .	Carmarthen,M. & P. Sch.	11·24	190
,, .	Street, Millfield..........	2·84	89	*Card* .	Aberystwyth	6·30	...
Glos .	Blockley	2·99	...	*Rad* .	BirmW.W.Tyrmynydd	9·31	141
,, .	Cirencester, Gwynfa....	4·17	126	*Mont* .	Lake Vyrnwy	14·27	251
Here .	Ross-on-Wye..............	2·78	84	*Flint* .	Sealand Aerodrome......	3·07	105
,, .	Kington, Lynhales......	4·40	117	*Mer* .	Blaenau Festiniog	20·63	221
Salop .	Church Stretton.........	4·38	121	,, .	Dolgelley, Bontddu......	8·06	133
,, .	Shifnal, Hatton Grange	2·60	92	*Carn* .	Llandudno	4·24	126
,, .	Cheswardine Hall........	3·36	108	,, .	Snowdon, L. Llydaw 9..	30·30	...
Worc .	Malvern, Free Library...	2·54	85	*Ang* .	Holyhead, Salt Island...	6·62	166
,, .	Ombersley, Holt Lock.	2·04	76	,, .	Lligwy	8·88	...
War .	Alcester, Ragley Hall...	2·63	96	*I. Man*	Douglas, Boro' Cem....	9·00	198

Erratum: Folkestone, Borough Sanatorium, September, *for* 1·91 read 2·22 inches.

Rainfall: October, 1938: Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Guern.	St.Peter P't.Grange Rd.	3.88	86	*R&C* .	Stornoway,C.GuardStn.	8·66	176
Wig .	Pt. William, Monreith.	7·67	194	*Suth* .	Lairg	8·58	230
„ .	New Luce School	9·15	196	„ .	Skerray Borgie	6·81	...
Kirk .	Dalry, Glendarroch	9·45	180	„ .	Melvich	6·53	178
Dumf.	Eskdalemuir Obs	10·98	203	„ .	Loch More, Achfary	13·59	174
Roxb .	Hawick, Wolfelee	6·21	162	*Caith* .	Wick	4·45	150
„ .	Kelso, Broomlands	4·23	145	*Ork* .	Deerness	6·35	168
Peeb .	Stobo Castle	6·51	189	*Shet* .	Lerwick Observatory	6·91	174
Berw .	Marchmont House	5·16	135	*Cork* .	Cork, University Coll	4·84	124
E.Lot.	North Berwick Res	4·78	161	„ .	Roches Point, C.G. Stn.	4·80	117
Midl .	Edinburgh, Blackfd. H.	4·50	164	„ .	Mallow, Longueville	5·68	158
Lan .	Auchtyfardle	7·51	...	*Kerry.*	Valentia Observatory	7·51	135
Ayr .	Kilmarnock, Kay Park	10·37	...	„ .	Gearhameen	14·70	160
„ .	Girvan, Pinmore	7·84	157	„ .	Bally McElligott Rec	6·35	...
„ .	Glen Afton, Ayr San.	11·14	218	„ .	Darrynane Abbey	7·11	141
Renf .	Glasgow, Queen's Park	9·25	285	*Wat* .	Waterford, Gortmore	4·96	127
„ .	Greenock, Prospect H.	11·72	231	*Tip* .	Nenagh, Castle Lough.	9·78	288
Bute .	Rothesay, Ardencraig	10·20	231	„ .	Cashel, Ballinamona	6·11	172
„ .	Dougarie Lodge	11·70	283	*Lim* .	Foynes, Coolnanes	6·32	167
Arg .	Loch Sunart, G'dale	12·25	186	„ .	Limerick, Mulgrave St.	8·24	237
„ .	Ardgour House	16·05	...	*Clare* .	Inagh, Mount Callan	12·45	...
„ .	Glen Etive	18·92	234	*Wexf* .	Gorey, Courtown Ho	4·53	122
„ .	Oban	10·70	...	*Wick* .	Rathnew, Clonmannon.	5·07	...
„ .	Poltalloch	10·34	210	*Carl* .	Bagnalstown,Fenagh H.	5·01	150
„ .	Inveraray Castle	25·59	321	„ .	Hacketstown Rectory	6·79	179
„ .	Islay, Eallabus	9·29	195	*Leix* .	Blandsfort House	5·82	165
„ .	Mull, Benmore	22·60	175	*Offaly.*	Birr Castle	7·28	250
„ .	Tiree	...	...	*Kild* .	Straffan House	6·31	222
Kinr .	Loch Leven Sluice	6·32	184	*Dublin*	Dublin, Phoenix Park	5·55	210
Fife .	Leuchars Aerodrome	3·52	135	*Meath.*	Kells, Headfort	7·19	215
Perth .	Loch Dhu	15·95	223	*W.M* .	Moate, Coolatore	6·02	...
„ .	Crieff, Strathearn Hyd.	7·06	180	„ .	Mullingar, Belvedere	8·66	278
„ .	Blair Castle Gardens	6·50	210	*Long* .	Castle Forbes Gdns	7·85	241
Angus.	Kettins School	4·25	134	*Gal* .	Galway, Grammar Sch.	6·07	163
„ .	Pearsie House	4·75	...	„ .	Ballynahinch Castle	11·97	200
„ .	Montrose, Sunnyside	3·54	128	„ .	Ahascragh, Clonbrock.	7·96	218
Aber .	Balmoral Castle Gdns.	4·21	117	*Rosc* .	Strokestown, C'node	6·46	212
„ .	Logie Coldstone Sch	3·68	114	*Mayo.*	Blacksod Point	7·62	153
„ .	Aberdeen Observatory.	2·96	99	„ .	Mallaranny	11·09	...
„ .	New Deer School House	3·57	94	„ .	Westport House	7·06	157
Moray	Gordon Castle	2·28	72	„ .	Delphi Lodge	14·54	153
„ .	Grantown-on-Spey	4·80	162	*Sligo* .	Markree Castle	8·08	197
Nairn.	Nairn	3·65	155	*Cavan.*	Crossdoney, Kevit Cas.	7·77	...
Inv's .	Ben Alder Lodge	10·88	...	*Ferm* .	Crom Castle	8·33	256
„ .	Kingussie, The Birches.	7·10	...	*Arm* .	Armagh Obsy	5·49	202
„ .	Loch Ness, Foyers	7·50	223	*Down.*	Fofanny Reservoir	10·79	...
„ .	Inverness, Culduthel R.	4·59	187	„ .	Seaforde	6·33	178
„ .	Loch Quoich, Loan	23·40	...	„ .	Donaghadee, C. G. Stn.	5·31	184
„ .	Glenquoich	20·49	205	*Antr* .	Belfast,Queen's Univ	7·75	236
„ .	Arisaig House	11·77	200	„ .	Aldergrove Aerodrome.	5·74	191
„ .	Glenleven, Corrour	13·24	217	„ .	Ballymena, Harryville.	7·34	199
„ .	Fort William, Glasdrum	14·61	...	*Lon* .	Garvagh, Moneydig	7·17	...
„ .	Skye, Dunvegan	14·98	...	„ .	Londonderry, Creggan.	8·22	223
„ .	Barra, Skallary	8·54	...	*Tyr* .	Omagh, Edenfel	7·53	205
R&C.	Tain, Ardlarach	5·00	165	*Don* .	Malin Head	7·07	184
„ .	Ullapool	10·32	213	„ .	Dunfanaghy	5·90	152
„ .	Achnashellach	15·47	193	„ .	Dunkineely	8·16	...

Climatological Table for the British Empire, May, 1938

STATIONS.	PRESSURE. Mean of Day M.S.L.	PRESSURE. Diff. from Normal.	TEMPERATURE. Absolute. Max.	TEMPERATURE. Absolute. Min.	TEMPERATURE. Mean Values. Max.	TEMPERATURE. Mean Values. Min.	TEMPERATURE. Mean Values. ½ Max. and Min.	TEMPERATURE. Mean Values. Diff. from Normal.	TEMPERATURE. Mean Wet Bulb.	Relative Humidity	Mean Cloud Am'nt	PRECIPITATION. Am'nt.	PRECIPITATION. Diff. from Normal.	PRECIPITATION. Days	BRIGHT SUNSHINE. Hours per day.	BRIGHT SUNSHINE. Per-centage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1014·8	− 1·1	75	32	60·3	44·8	52·5	− 2·0	46·8	76	7·4	1·30	− 0·42	13	5·2	34
Gibraltar	1016·1	0·0	80	51	68·2	56·7	62·5	− 3·0	55·2	74	4·2	2·63	...	7	...	...
Malta	1015·6	+ 1·1	75	55	68·1	58·6	63·3	− 2·6	58·8	77	4·6	0·46	+ 0·05	5	10·5	75
St. Helena	1016·7	− 1·5	70	56	67·1	59·4	63·3	+ 1·0	60·4	87	7·4	1·65	− 1·03	11	...	...
Freetown, Sierra Leone	1011·6	+ 2·1	90	71	86·3	74·4	80·3	...	75·6	79	6·8	9·58	− 1·89	17	...	...
Lagos, Nigeria	1010·9	+ 0·3	91	70	86·2	74·5	80·3	− 1·5	76·7	87	6·5	10·87	+ 0·12	15	5·5	44
Kaduna, Nigeria	1009·5	...	95	64	89·1	71·7	80·4	+ 0·5	72·6	81	8·3	6·92	+ 1·15	15	7·7	61
Zomba, Nyasaland	1014·1	− 1·3	84	53	76·5	57·5	67·0	+ 1·2	64·7	65	3·5	1·12	+ 0·08	4	...	...
Salisbury, Rhodesia	1016·5	− 1·1	81	40	75·3	48·5	61·9	+ 1·3	53·8	54	0·9	0·01	...	1	9·8	87
Cape Town	1017·6	− 0·5	80	43	67·1	53·0	60·1	+ 1·2	53·5	82	5·5	4·79	+ 1·04	16	...	...
Johannesburg	1017·3	− 0·8	76	35	66·6	47·8	57·2	+ 2·8	46·7	58	2·0	0·36	− 0·40	2	8·7	80
Mauritius	1015·6	− 0·7	84	62	80·1	67·3	73·7	+ 1·1	70·5	76	4·4	3·12	− 0·80	17	8·0	71
Calcutta, Alipore Obsy.	1000·7	− 2·8	100	69	93·1	77·1	85·1	− 1·0	79·2	84	7·3	14·54	+ 8·98	14*	...	...
Bombay	1005·2	− 2·2	94	78	91·9	80·9	86·4	+ 0·6	78·3	74	3·8	1·29	+ 0·74	3*	...	...
Madras	1002·9	− 2·5	108	76	101·0	82·8	91·9	+ 2·1	77·8	58	5·4	0·12	− 1·72	1*	...	...
Colombo, Ceylon	1007·9	− 0·5	89	75	87·1	79·5	83·3	+ 0·5	79.1	78	7·0	3·48	− 7·46	18	6·5	52
Singapore	1008·7	0·0	90	73	86·7	75·6	81·1	− 0·9	78·0	80	6·8	9·61	+ 2·97	19	5·7	47
Hongkong	1009·1	0·0	89	67	83·5	75·1	79·3	+ 1·9	75·5	82	7·9	8·71	− 3·36	14	5·2	40
Sandakan	1008·0	...	90	73	86·9	75·9	81·4	− 1·1	77·7	86	7·5	9·46	+ 3·13	14	...	...
Sydney, N.S.W.	1021·8	+ 3·2	77	45	68·4	54·2	61·3	+ 2·5	56·2	80	6·2	3·81	− 1·37	16	4·9	47
Melbourne	1021·5	+ 2·3	79	39	65·9	47·1	56·5	+ 2·4	50·4	76	6·5	0·78	− 1·38	10	4·3	42
Adelaide	1021·7	+ 1·5	77	41	67·9	50·8	59·3	+ 1·3	53·7	67	6·5	0·98	− 1·74	10	4·8	47
Perth, W. Australia	1017·1	− 1·3	80	45	69·5	52·8	61·1	+ 0·4	54·8	69	5·9	1·75	− 3·22	10	6·5	62
Coolgardie	1018·7	− 0·4	77	37	67·5	48·1	57·8	+ 0·1	52·1	77	5·3	0·76	− 0·57	4	...	...
Brisbane	1019·6	+ 1·0	83	54	73·6	60·1	66·9	+ 2·3	62·0	80	5·7	11·81	+ 9·00	11	5·1	47
Hobart, Tasmania	1018·6	+ 3·3	66	39	59·4	45·4	52·4	+ 1·9	47·2	77	5·5	1·15	− 0·75	11	4·9	51
Wellington, N.Z.	1020·2	+ 4·6	66	40	60·3	48·5	54·4	+ 1·6	52·0	79	6·2	0·87	− 3·81	11	5·5	56
Suva, Fiji	1012·8	+ 0·1	87	63	82·5	73·0	77·7	+ 1·2	73·0	82	6·3	11·58	+ 1·51	22	3·7	33
Apia, Samoa	1010·4	− 0·7	87	71	84·9	74·2	79·5	+ 1·1	75·8	79	5·0	8·79	+ 2·72	19	6·8	59
Kingston, Jamaica	1013·5	+ 0·4	90	69	87·4	72·3	79·9	+ 0·2	71·3	74	3·0	0·60	− 3·79	5	6·6	51
Grenada, W.I.	1011·1	− 1·5	88	71	86	73	79·5	− 0·2	74	78	7	12·91	+ 8·72	23	...	...
Toronto	1013·9	− 1·0	78	36	63·9	46·4	55·1	+ 1·3	46·8	67	5·6	2·15	− 0·64	10	7·0	48
Winnipeg	1013·3	− 0·5	79	27	63·0	40·7	51·9	− 0·1	41·0	83	6·3	1·60	− 0·40	10	6·5	42
St. John, N.B.	1012·9	− 1·0	69	33	56·3	40·1	48·2	+ 0·5	43·0	77	7·0	3·35	− 0·36	16	6·6	44
Victoria, B.C.	1019·6	+ 2·9	73	39	60·1	46·0	53·1	+ 0·1	49·4	74	4·9	0·54	− 0·59	6	10·8	71

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Winnipeg	1013·3	— 0·5	79	27	63·0	40·7	51·9	— 0·1	41·0	83	6·3	1·60	— 0·40	10	6·5	42
St. John, N.B.	1012·9	— 1·0	69	33	56·3	40·1	48·2	+ 0·5	43·0	77	7·0	3·35	— 0·36	16	6·6	44
Victoria, B.C.	1019·6	+ 2·9	73	39	60·1	46·0	53·1	+ 0·1	49·4	74	4·9	0·54	— 0·59	6	10·8	71

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